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VOLCANIC ROCKS OF MESOZOIC AGE IN PENNSYLVANIA.

BY E. GOLDSMITH.

My petrographical and geological observations have convinced me that nearly all so-called "trap" is of volcanic origin. Supporting proofs may be found in many localities near Philadelphia, such as the Haycock Mountain, New Hope and the railroad cuts north and south of Quakertown in Bucks County, Pa. The richest field of observation, however, is the hill four miles north of Pottstown, Montgomery County. The various outcrops of the volcanic rocks may there be studied to greater advantage than in the other localities.

One hundred and fifty acres of the top and side of the hill now form a public park, much of the rubbish and underbrush being, therefore, removed. A series of volcanic terraces of Mesozoic age has been thus uncovered and is, I think, worth recording. These terraces were formed by four distinct outflows of lava. The four, five or six sided columns of greenstone-basalt can be seen on the edge of each step from the first outpour. The first outflow had a range wider in extent than the others; the second was less, to all present appearances; the third eruption was decidedly less great, whilst the fourth, the top of the hill, exceeded the second and third in mass of material. The greatest difference between the levels of the various outpours is seen between the third and the fourth flow. The whole extent of these terraces is overshadowed by a grove of trees and carpeted with grass and other small plants, an illustration would, therefore, be indistinct.

A strictly scientific examination of the terraces would involve a survey, the removal of rubbish and sod down to the lava and the determination of the various levels with instruments of precision.

The terraces are situated on the western side of the park. The level forms a plateau on which a fine iron structure has been built to a height of some twenty or more feet above the trees, an observation tower, from the upper platform of which a grand view of part of the Schuylkill valley can be obtained. Near this point, in a pile of débris, the first indications of a devitrified obsidian or tachilyte were found. On a later visit I observed a slab of about three feet in length and about six inches thick imbedded in a bank of débris of similar material; many indications of the volcanic rock being scattered about. The rock is jet black, dull, very fine grained, with distinct conchoidal fracture, the edges becoming very sharp; the hardness is a little less than quartz. The per centage of silica was 57.1. Under the microscope was observed a microperlitic structure. All attempts to secure a photograph of this structure failed.

A second variety of tachilyte was found, but not so abundantly as the first. It is also deep black and very fine grained, very thin white streaks or lines being irregularly distributed through the mass. Under the microscope, the thin section showed again that the essential material consists of devitrified glass darkened by an extremely fine powder of what seemed to be magnetite. The white lines, suggestive of crystals, appeared when magnified as elongated globular forms filled with a partially crystalline substance of indistinct crystalline forms. The globules consist of subcrystalline material, filling what was originally gas pores. A section showed also the fluid structure. With very strong, light, numerous crystallites were observed.

A third variety of devitrified glass has a yellow-gray color. This tachilyte is very hard and so peculiarly splintery, sharp edged and curved, that no fragment could be secured with the hammer from which to grind a section, the lapidary having to cut the plates for the purpose. The mineral is very fine grained and even, some specimens having a yellow edge apparently of the same hardness as the general mass. Where water had affected the material there is a thin rusty coating.

With ordinary light, a thin section shows beneath the microscope, that the mass of rock is made up of largely predominating fine ash-like granules interspersed with minute fragments of crystalline material, the whole cemented together by devitrified glass.[1]

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[1] About six years ago, I found a specimen of rock near Rockhill Station, in Bucks County, and determined it under the name of Felsite. It seems to me, that Felsite, Eurite, Petrosilex and Tachilyte are all the same in composition structure and origin. All these rocks seem to belong to the glassy lavas, and are, therefore, in all probability, of volcanic origin. Since the inner structure and mineral composition should decide the name of a rock, it is thought best to call this, and all three varieties, Tachilyte, because the principal mass is devitrified obsidian, as has already been suggested by several British petrographers, and, since Breithaupt's name seems to have the priority, it should, I think, be retained by geologists.

Eastward from the upper plateau of the terrace is an open area devoid of plant life. It is called by the people the "Great Ringers," Plate II, in contradistinction to the "Little Ringers," which are situated on east side of the park. The outcrop consists of rocks of various sizes, from a hand specimen to those weighing thirty tons or more. They are essentially gabbro-phonolite, as I stated in a communication made several years ago to the Academy. I then announced the mineralogical composition of these rocks to be: plagioclastic-feldspar, sanidine, diallage, augite, magnetite; ferrite also was occasionally present. These rocks are very tough and close-grained. Even a thin section has a considerable cohesion and does not break in boiling in spirits of turpentine, unless the outer weathered gray crust be taken. This is brittle when thus tested.

Plate I illustrates a small section of this singular rock formation. The outcrop has precisely the appearance of what has been called an Einsturzkrater[2] or collapsed crater. The crater in its present condition is but a fraction of what it was formerly. Its former horizon can still be traced; vegetation has gradually encroached upon it and, if not prevented, will cover the entire tract which is now bare. The outlines of volcanic craters are extremely irregular everywhere, whether the walls are still standing or have fallen in. The contour may be traced, however, in either case, the rocks themselves being the guides. It can be shown that in the building up of the elevation, various phases of volcanic action must have taken place to accomplish that which ultimately resulted. It seems probable, as has been suggested, I think by Geike, and even observed by him and others, that the phonolites are formed on the upper neck of the volcano, and that the basalts are liquid lava poured out from some point along the side of the crater. Similar relations appear to have existed in the building up of the Pottstown Hill. The metallic sounds emitted from the rocks, when struck with a hammer, are of great interest to visitors, and both superstition and poetry are incited thereby. The phonolites of this locality however, lose their ringing property when broken. It seems probable that this effect is due to the production of innumerable cracks through the whole mass, just as a metallic bell or a glass jar loses the property of ringing when cracked. There are, however, some phonolites, as those occurring north of Wilmington, Delaware, and on Haycock

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[2] Carl Vogt's Geologie, Band II, page 330.

Mountain, in Bucks County, Pennsylvania, which retain the metallic sound when broken.

The Little Ringers, as they are termed, are essentially the same as those described above. The outcrop, thickly covered by trees, is situated about a quarter of a mile east of the others, and may be an indication of a separate neck of a crater. The outcrop appears small because the trees have taken possession of the surroundings. There is probably more of it than can be seen at present. If not prevented, the trees will cover the Little Ringers in the course of time as certainly as nine-tenths of the whole area of the hill is now covered.

Not far from the Railway Station on the hill, borings for water were made without result. Some of the rock fragments brought to the surface indicated a bed of amygdaloid of a pale grayish color; the thickness of the bed was not ascertained and is at present unknown. Specimens of amygdaloid are found on the surface, one of which had the almond shaped nodules of more than an inch in length and protruding from the rock nearly half an inch.

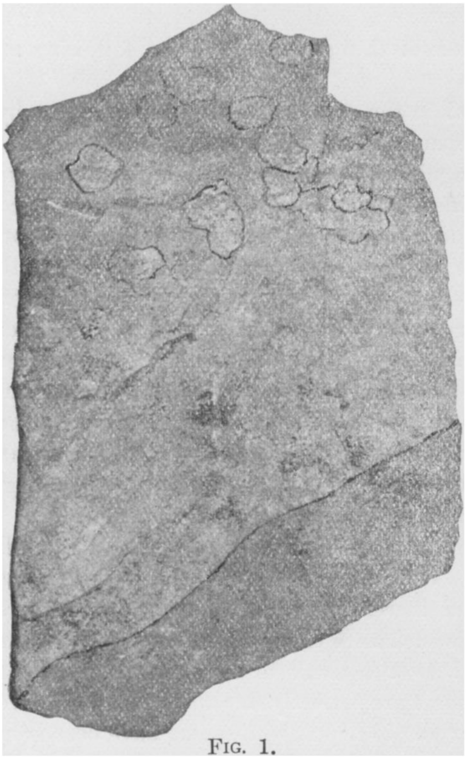


FIG. 1.
Amygdaloid showing fluidal texture.

An interesting specimen of amygdaloid with an uncommon fluidal texture is represented by the figure 1. It gives a fair idea of the specimen, the lighter shade above and the darker below being sharply defined. The fluidal texture is usually observable only in thin sections under the microscope, but in this case, we have it macroscopically. When magnified the thin section showed a great many small blisters or former cavities filled with a still whiter material than the honeycombed mass in general. The lighter part of the mass contained but little magnetite, while the dark portion was filled with this iron ore. As plutonic rocks do not possess any amygdaloid texture, I have concluded that those found in the Pottstown park are of volcanic origin, that they were once a fluid lava and that the rock masses as they appear are the remnants of a collapsed crater.

Microscopic examination of thin sections gave the following result:—

The infiltrated material in the former gas cavities appeared by reflected light as white, opaque, granular masses, which could not be resolved even when magnified to about three hundred diameters into any distinct crystalline form. Nevertheless, that it possessed crystalline structure is indicated by its aspect in polarized light. I diagnose the material as feldspatic. With ordinary light and with the aid of an Abbé condenser the rock mass showed a faint green augite; the particles, very finely divided, often appeared together in groups, and these small greenish individuals having a greater refractive index than the feldspar, were, in consequence, more conspicuous than the greater mass of the rock. In polarized light the feldspar appeared to be essentially orthoclase, some sanidine being also present. This volcanic rock may be compared with the amygdaloidal basalt of Schlachenwerth, near Carlsbad, Bohemia.

A general description of the rocks on the eastern side of the hill is also of special interest. The enormous size of some of the sections of basaltic columns found there, some undoubtedly *in situ*, others removed to a lower level, is such as to cause surprise. These basalts are mostly six-sided, and as the result of weathering, somewhat rounded on their edges; some are perfectly flat and level, others are found with a concavity varying in depth, while some have been seen with a wavy surface. Some of the columns do not seem to split transversely, but stretch their bulky length some twenty feet or more along the ground. One has been named the Bullfrog by the natives. The diameters of the six-sided sections of the basalt vary. I measured some which were ten, eleven or fifteen feet across. These gigantic illustrations of mountain-making may indicate a peculiar geologic condition wherein a long continued internal heat, or possibly a slow cooling dependent upon external causes, prevented the contraction of the general mass into smaller columns such as are so often found occurring in the Tertiary and more recent periods. I confess that nowhere in my travels, either in this country or in Europe, did I observe such colossi of basaltic columns. When in their entirety they must have been giant structures in the strictest sense of the phrase. An interesting and very suggestive rock received the name of the Haystack from the owner of the place. Plate III represents the same as viewed from the southern side. As the illustration indicates, the side to the right is convex, and if one stands where he can see the convexity only, a similiarity to a haystack or the section of one may suggest itself.

On close examination I found that the inclined position of the rock was due to tilting, and that formerly it must have stood erect; it can also be shown that the rocks to the left were parts of the same, and, if the losses through erosion are also taken into account, the Haystack had, in all probability, another outline than the one which it now presents. It seems clear to me that this tall object was originally triangular in form, that it is the last remnant of a crater wall standing there almost separated from the other parts of the crater which lie to the north, northwest and west, while the southern side has entirely collapsed.

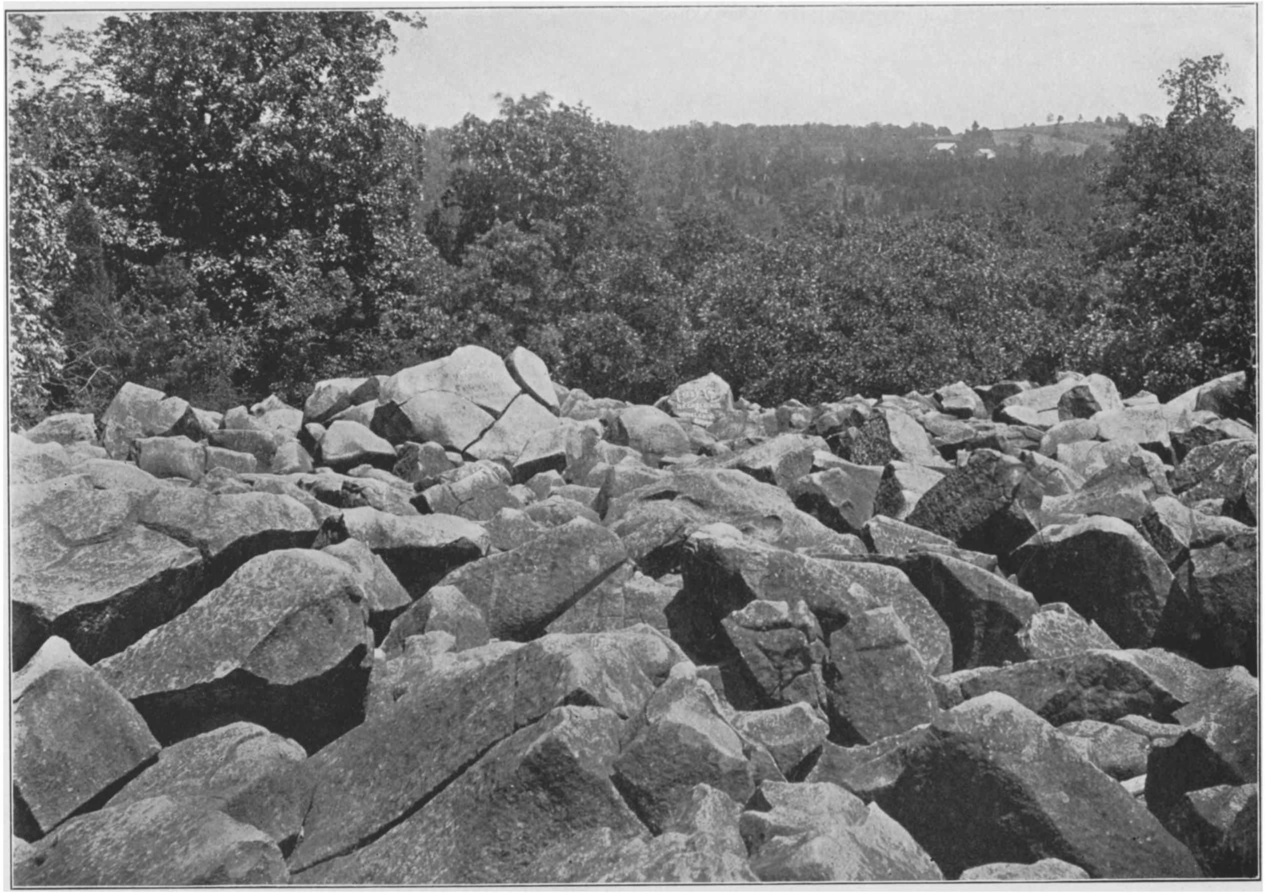
Whoever has closely observed the structure of recent volcanoes, is aware that if it were possible to make a vertical section of the crater wall, that section would necessarily be triangular in form. If it were possible to obtain it, a birds eye view would render the significance of the aspect more convincing. A photograph of the crater wall-section from the west side, Plate IV, represents it fairly well. The camera stood about half way up on the opposite slope, a position which accounts for the depression shown in the central fore ground of the picture. The part from the standing rock to the left, above, is corroded away, plant life here, as everywhere, having doubtless contributed its share toward the destruction of these rocks. The huge blocks seen in front of the tall section, are those which I believe to have been formerly united with the so-called Haystack to form the triangular part of the crater wall. Everybody who has paid the least attention to the study of rocks is acquainted with their continual disintegration, effected by heat and moisture working inward from the exposed surfaces of even the hardest and toughest rocks. The tall crater wall-section shows even now a great many cracks, especially on its convex side, and it seems evident that it will not require many years to complete its destruction. Its present inclined position will probably cause the fall of the upper part first, thus obliterating another proof of what the structure was in former times. Professor Oscar Carter said, when I showed him the object in question and pointed out its significance: " A very suggestive specimen, what else could it represent? It appears to be a last remnant of the wall of a crater." Of course, it requires some little imagination to see such a connection, but the principal emphasis is laid on the surroundings and upon the cumulative proofs of the volcanic rocks themselves.

From the Haystack a narrow winding path in a general northeasterly direction leads to an immense platform of basalt known as Table Rock. Of this no photograph was taken, in order to spare the remaining plate for the picture of the entrance to the cave. In Plate V the entrance of what the people call the cave, is plainly noticeable among the huge and partly broken rocks. The large block lying on the left shows the triangular contour of the cross cut of a crater wall in a manner sufficiently characteristic. The collapsing process and the gradual breaking up of the great masses of rock are at least partially recognizable in the illustration. To obtain a general idea of what that cave really is, however, one must ascend the debris surrounding the great wall of massive blocks, climb upward along a rustic step-walk, mount upon the top of the wall and gaze down into the cavity. The deep kettle-shaped cavity is formed by the rock masses which are more or less split in various directions, but the greater number are vertically cleft. That this is an ancient crater I have not the slightest doubt; that the formation has never been a cave in the geological sense of the word is clear from the fact that volcanic rocks never form hollow domes. It is, however, possible to creep into the cauldron from the side entrance, and boys are occasionally seen sliding or climbing down into the hollow space from above.

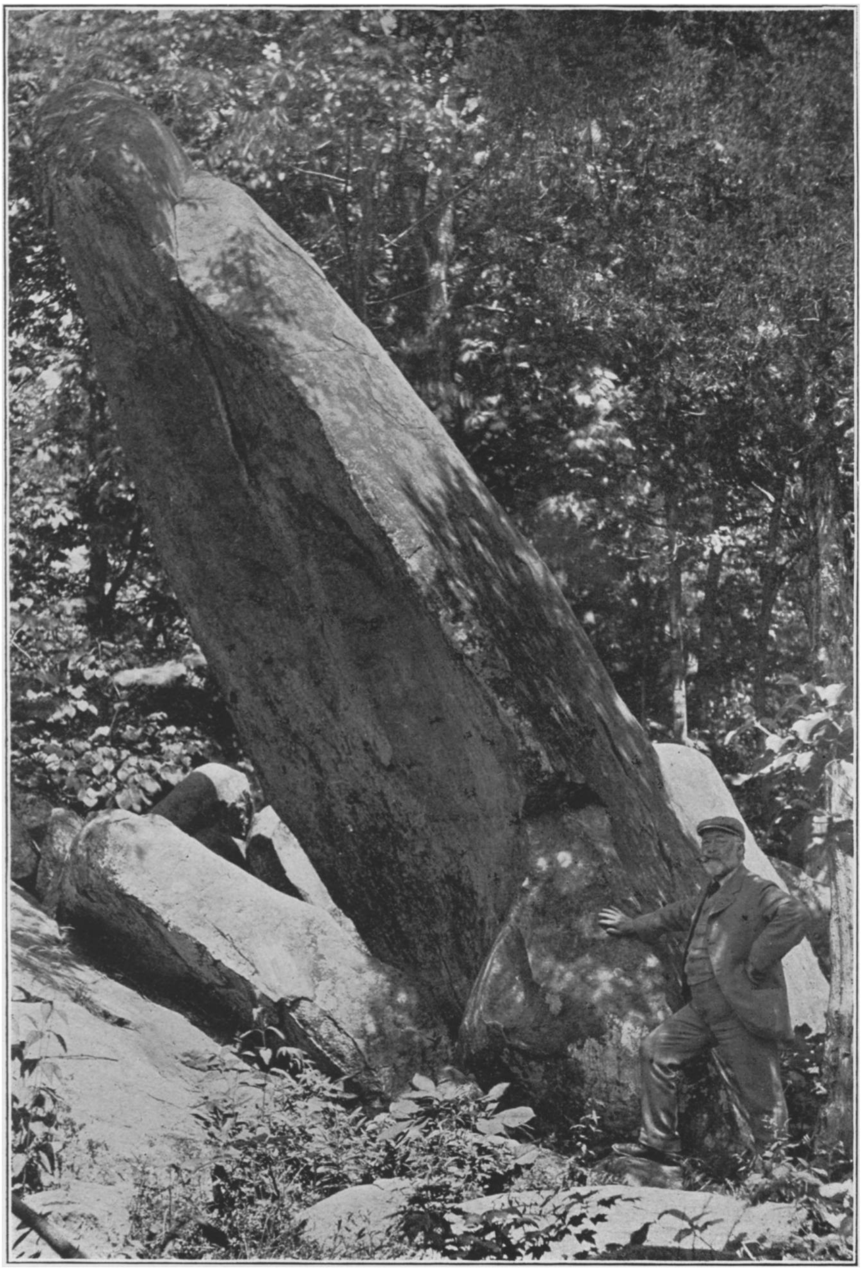
Volcanic craters vary a great deal in diameter; this one is small, its inside measure amounts, I think, to not much more than forty feet, and in its depth somewhat less. Since the wall rocks of this crater are cracked vertically and in the inner parts moved toward the centre, it is self-evident that the inner diameter must have been greater in the past. Here, as in other parts of the hill, the trees are doing their work steadily, breaking the larger blocks into smaller ones; the decay is continually going on, and although the entire sleeping crater is still standing where it was built by the ancient fluid lavas of the Mesozoic era, it is only a question of time when this one also will have been disrupted and obliterated like its ancient colleagues of the vicinity.

Ancient craters necessarily decay and crumble away just as any other exposure of rock will do. It is well-known to those versed in the special literature of the subject, that collapsed craters have been found and recognized in Europe, and it might reasonably be expected that in time the discovery of similar phenomena existing here would result from careful observation.

In the literature of the Second Geological Survey of Pennsylvania nothing is mentioned of the Pottstown Hill, except that Trap occurs there. But that an entire crater of Mesozoic age is still intact at that spot nobody seems to have even guessed; at least no geologist appears to have looked at it, much less to have explored or described it. That the deep cauldron is an ancient crater, I am fully convinced.



GOLDSMITH. VOLCANIC MESOZOIC ROCKS.



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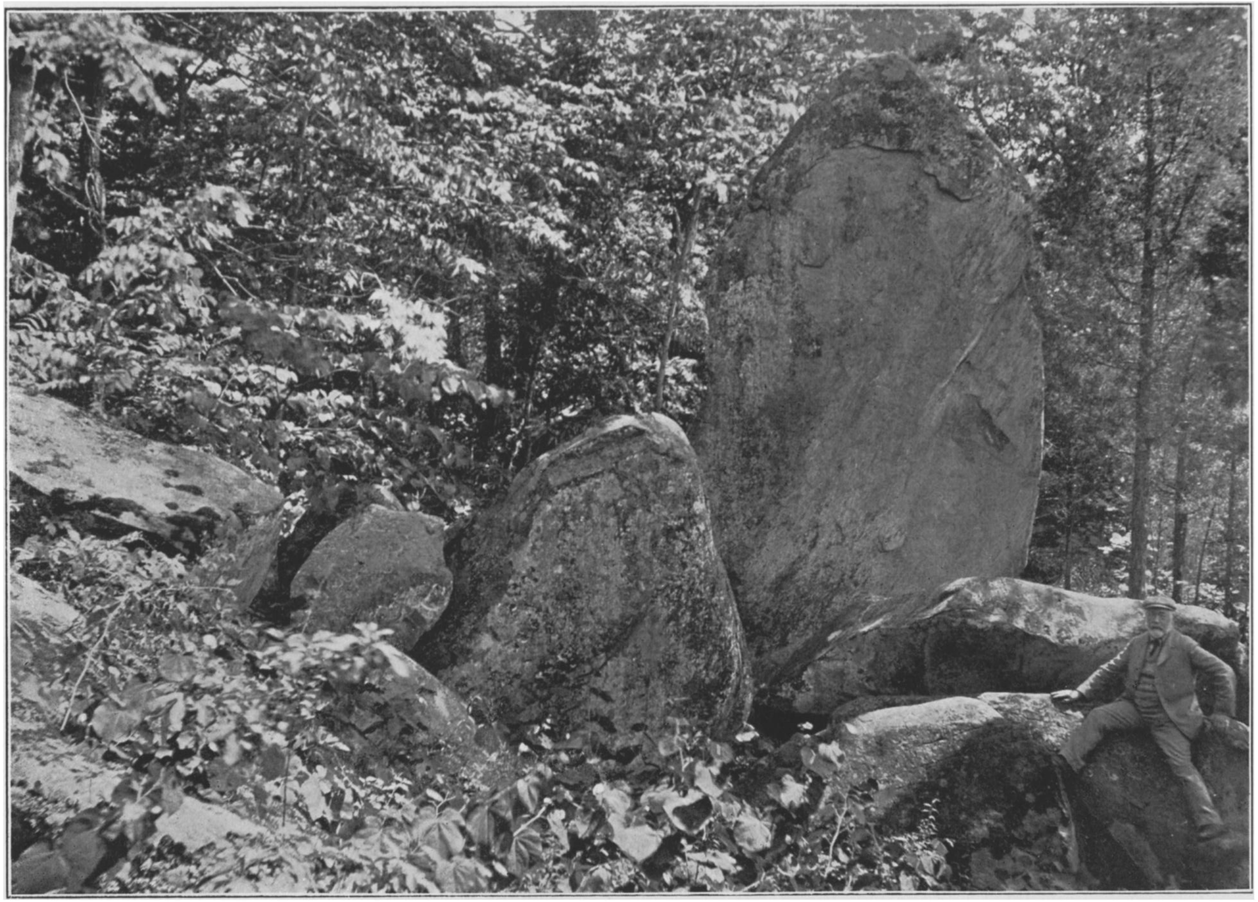

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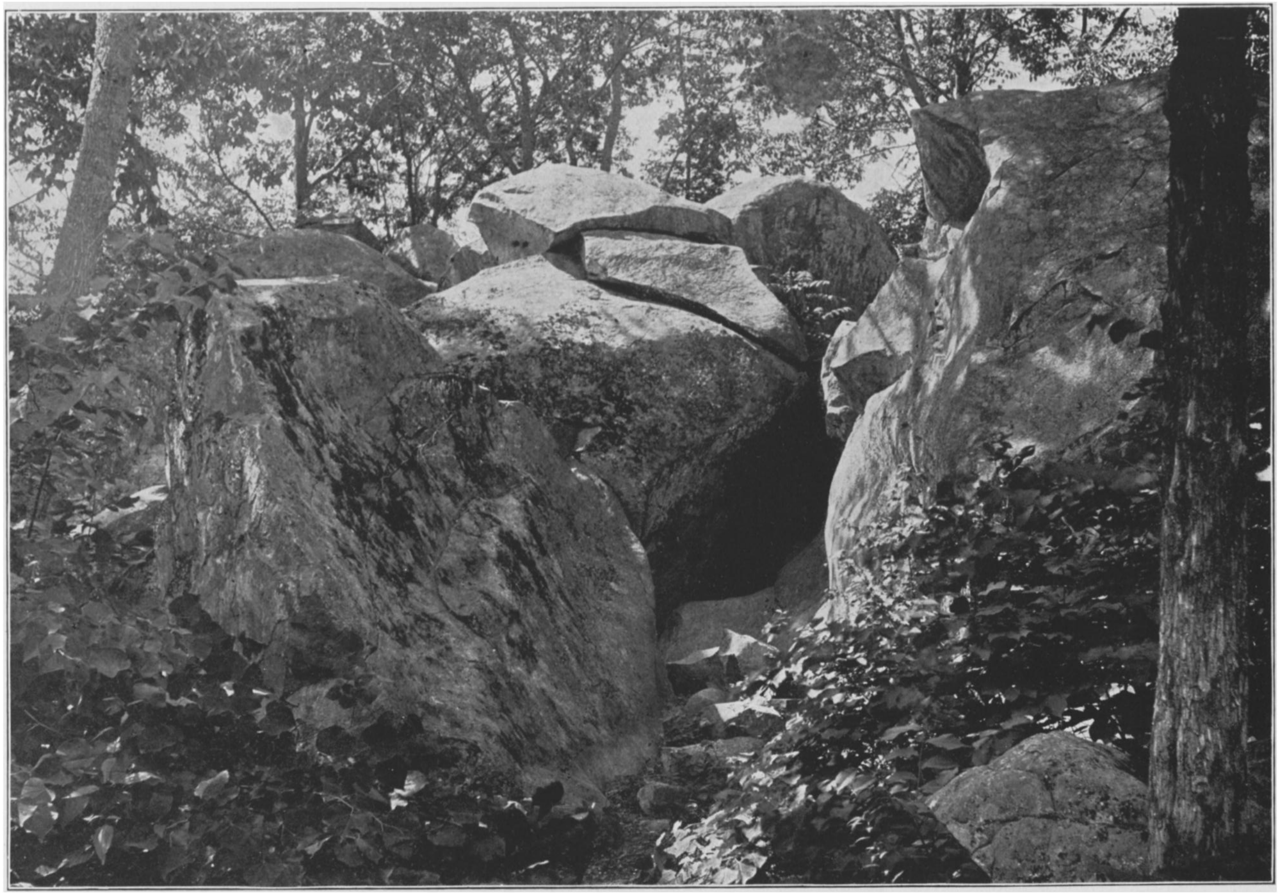

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